

Testing Validity of Purchasing Power Parity for Emerging Asian Countries: Evidence from Thailand, Taiwan and South Korea

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ABSTRACT

This study tests the validity of relative purchasing power parity (PPP) in Thailand, Taiwan, and South Korea. This study examines on the results of the inflation extracted from stock returns and traded-goods price index (TPI) by using least-squares regression method to test PPP in short run and unit root and cointegration test method to test PPP in long run. The results provide the additional supporting evidences that PPP seems to be valid in short run when using pure price inflation rate extracted from stock return due to high-volatility of pure price inflation rate comparing to inflation from good prices. Using inflation rate from goods price always does not satisfy short run PPP since goods price takes longer time period in adjustment than stock prices. In addition, the results provide the supporting evidences that PPP can be valid by arbitrage mechanism. Therefore, PPP should be valid with the country that has higher level of factors that support international trading activity rather than the country that has lower level of those factors.

Keywords: purchasing power parity, extracted inflation rate, inflation proxy, exchange rate

บทคัดย่อ

วัตถุประสงค์หลักของการศึกษาคือเพื่อทดสอบทฤษฎีอำนาจซื้อเสมอภาคแบบเปรียบเทียบ (relative purchasing power parity: relative PPP) ในประเทศตลาดเกิดใหม่ในเอเชีย โดยเลือกประเทศไทย ไต้หวัน และเกาหลีใต้เป็นประเทศกลุ่มตัวอย่าง การทดสอบพิจารณาผลจากการใช้อัตราเงินเฟ้อคำนวณจากผลตอบแทนหลักทรัพย์ และดัชนีราคาสินค้าระหว่างประเทศ (traded-goods price index: TPI) ทั้งในระยะสั้นและระยะยาว โดยใช้วิธี least-squares regression เพื่อทดสอบทฤษฎีอำนาจซื้อเสมอภาคใน

ระยะสั้น และวิธี unit root test และ cointegration test เพื่อทดสอบทฤษฎีอำนาจซื้อเสมอภาคในระยะยาว ผลการทดสอบให้หลักฐานสนับสนุนว่าทฤษฎีอำนาจซื้อเสมอภาคมีความเที่ยงตรงในระยะสั้นเมื่อทดสอบโดยใช้อัตราเงินเฟ้อจากผลตอบแทนหลักทรัพย์ซึ่งมีความผันผวนสูงกว่าอัตราเงินเฟ้อจากราคาสินค้า ในขณะที่อัตราเงินเฟ้อจากราคาสินค้าไม่สนับสนุนทฤษฎีอำนาจซื้อเสมอภาคในระยะสั้นเนื่องจากราคาสินค้าใช้ระยะเวลาในการปรับตัวมากกว่าราคาหลักทรัพย์ นอกจากนี้ ผลการทดสอบยังให้หลักฐานสนับสนุนว่าทฤษฎีอำนาจซื้อเสมอภาคสามารถมีความเที่ยงตรงได้จากกลไกการทำอาร์บิทราจ (arbitrage)

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mechanism) ดังนั้นทฤษฎีอำนาจซื้อเสมอภาคย่อมมีความเที่ยงตรงกับประเทศที่มีปัจจัยสนับสนุนการค้าระหว่างประเทศมากกว่าประเทศที่มีปัจจัยสนับสนุนการค้าระหว่างประเทศน้อยกว่า

คำสำคัญ: ทฤษฎีอำนาจซื้อเสมอภาค อัตราเงินเฟ้อจากผลตอบแทนหลักทรัพย์ ตัวแทนอัตราเงินเฟ้อ อัตราแลกเปลี่ยน

INTRODUCTION

The purchasing power parity (PPP) is an exchange rate theory. The PPP explains that the exchange rate between two countries is in equilibrium when the purchasing power of these two countries at that rate is equal. This means that the identical basket of goods in these countries has equal price when the price is measured in the domestic currency.

A number of studies cast doubt on the validity of the PPP. Two important explanations are *sticky price* and *exchange rate overshooting*. In goods market, the existence of transaction cost as well as the imperfect competition causes goods price sticky. At the same time, money market, which determines exchange rate, has a lower degree of these imperfections. As a result, goods price is sticky compared to exchange rate. Therefore, the PPP deviates from the theoretical level.

However, *the choice of inflation proxies* is also matter in PPP test. The different inflation proxy can give the different results even in the same country and sample period because the different inflation proxy represents inflation from different price, which is constructed using different method and contains different component. The conventional price such as consumer price and producer price, which are constructed as consumer price index (CPI) and producer price index (PPI) respectively, are always used to test PPP in practice. The evidences of them always do not support the PPP because these indexes are too sticky to capture the movement of exchange rate. Thus, more suitable price proxy to the PPP relationship is interesting to be investigated.

The evidences of PPP are usually tested by the main currency of the world, the examples are in these two classic works of Frenkel and Enders. Frenkel (1981) tests PPP using U.S. Dollars, U.K. Pound, French Francs, and Germany Deutsche Marks, while Enders (1988) uses U.S. Dollars, Germany Deutsche Marks, Japan Yen, and Canada Dollars. In the meantime, the evidences from the rest of the world are rarely to find. In the case of emerging Asian countries, *Thailand, Taiwan, and South Korea* are the important countries in this region in the view of trading relationship with the U.S. Among the Asian countries, except for China and Japan, Taiwan and South Korea are the top fifteen trading partners of the U.S. since 2004 until the first half of 2010 (Foreign Trade Division, U.S. Census Bureau). At the same time, Thailand's international trade channel is significantly affected by the trading activity with the U.S. because the U.S. is the second ranking trading partner of Thailand for more than ten years before 2007 (Ministry of Commerce, Thailand). From these reasons, Thailand, Taiwan, and South Korea are selected from the emerging Asian countries to be tested.

This study attempts to test the validity of PPP theory in Thailand, Taiwan, and South Korea using different inflation and price proxy. The first proxy is the *extracted inflation* from the literature of Chowdhry *et al.* (2005) (C-R-X). C-R-X extract the pure price inflation from stock returns to test PPP using the data from the U.S., the UK, Germany, and Japan and conclude that relative PPP holds for pure price inflation extracted from stock return. The reason behind using stock returns data to extract pure price inflation is that the stock returns fully reflect to the relevant factors in financial market, which determine the level of exchange rate. Thus, the extracted inflation is more flexible to the factors in financial market than the conventional price indexes.

The second inflation proxy comes from the study of Xu (2003). This study constructs the traded-goods price index (TPI) from the import price index and the export price index using the data of the U.S.

and eight trading partners. Xu (2003) also uses consumer price index (CPI) and wholesale price index (WPI) as alternative price proxy. The results are different between the cases using TPI, CPI, and WPI. Xu (2003) concludes, “TPI appears to be a more appropriate price index for both PPP tests and exchange rate forecasting”. The explanation about the results comes from the concept of PPP; purchasing power is equalized between countries through arbitrage mechanism. Thus, the volume of trading activity reflects the opportunity of arbitrage and the price of traded goods may reflect more closely to PPP relationship. Moreover, TPI would have high performance when tested in the country that has high trading activity using its trading partner as exchange rate denominator.

METHODOLOGY

This study tests the PPP in Thailand, Taiwan, and South Korea using U.S. Dollars as denominator. The sample period is based on monthly data started from March 1998 to December 2007. Before the tests, the inflation and price indexes are constructed. The construction method is examined after the part of PPP specifications.

PPP specifications

The relative version of purchasing power parity (PPP) examines the change across time of exchange rate and the change across time of price level. The specification can be shown as;

$$\Delta s_t \approx \Delta p_t - \Delta p_t^* \quad (1)$$

Δs_t denotes the change of log of domestic currency in the form of direct quoted (domestic currency to foreign currency), Δp_t denotes the change of price (inflation rate) of home country, and Δp_t^* denotes the change of price (inflation rate) of foreign country.

Follow the methodology of C-R-X, the change of spot rate is used as explanatory variable and the intercept is introduced to the equation (1). As a result, equation (2) is derived as;

$$\Delta p_t - \Delta p_t^* = \beta_1 + \beta_2 \Delta s_t + \varepsilon_t \quad (2)$$

Δp_t denotes the inflation rate of home country, Δp_t^* denotes the inflation rate of foreign country, and Δs_t denotes the change of log of domestic currency in the form of direct quoted.

Short run PPP focuses on the relationship between the change across time of exchange rate and the change across time of price level in short run. When monthly data are applied on the equation (2), time horizon between t and $t+1$ is one month. This implies the “short” period allowed for an adjustment of the relevant variables between t and $t+1$. Therefore, this study tests short run PPP by regressing least-squares regression on equation (2). The hypothesis is:

$$H_0: \beta_1 = 0, \beta_2 = 1 \text{ (short run PPP valid),}$$

$$H_1: \beta_1 \neq 0, \beta_2 \neq 1 \text{ (short run PPP is not valid)}$$

Long run PPP is tested by two methods. The first method is the unit root test on the real exchange rate series. The reason behind using unit root test for long run PPP is that PPP predicts that the real exchange rate is not permanently changed. In the jargon of cointegration, the unit root test is equal to restricting the correlation coefficient of nominal exchange rate, foreign price index, and domestic price index equal to one (in absolute term).

The real exchange rate series are constructed from this specification;

$$q_t = s_t + p_t^* - p_t \quad (3)$$

q_t denotes the log of real exchange rate, s_t denotes the log of nominal exchange rate, p_t^* denotes the log of foreign price index, and p_t denotes the log of domestic price index.

This study uses the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) to test unit root. Moreover, the method of Perron (1989) is also used to take account of structural break in the real exchange rate series. The general specification of unit root can be shown as the following AR form;

$$\Delta q_t = a_0 + \alpha q_{t-1} + a_2 t + \sum_{i=2}^p \beta_i \Delta q_{t-i+1} + \varepsilon_t \quad (4)$$

$H_0: \alpha = 0$ (nonstationary), $H_1: \alpha < 0$ (stationary).

The results of unit root test support the validity of strong PPP if the H_0 is rejected.

The second method of long run PPP test is the cointegration test between nominal exchange rate and relative price. The correlation coefficient (β_1) is allowed to vary from one. This means that strong PPP encompasses weak PPP. The specification of cointegration test is:

$$s_t = \beta_0 + \beta_1(p_t - p_t^*) + \varepsilon_t \quad (5)$$

s_t denotes the log of nominal exchange rate, p_t denotes the log of domestic price index, and p_t^* denotes the log of foreign price index.

This study uses the Johansen cointegration method to test the cointegration relationship and estimate the cointegrating vector.

For the cointegration test using trace statistics, the hypothesis is:

H_0 : at most r cointegrating vectors exist (at $r=0$, H_0 means “no cointegration relationship”)

H_1 : more than r cointegrating vectors exist

For the cointegration test using max-eigenvalue statistics, the hypothesis is:

H_0 : r cointegrating vectors exist (at $r=0$, H_0 means “no cointegration relationship”)

H_1 : $r + 1$ cointegrating vectors exist

The results of cointegration test support weak PPP if the H_0 is rejected at $r=0$ and the normalized estimated cointegration coefficient (β_1) is not far from unity.

The inflations and price indexes construction

Extracted inflation (\hat{R}_{ft}) and hypothetical price index (HPI)

In this study, the extracted inflation series (\hat{R}_{ft}) is estimated in order to capture the unobservable pure price inflation rate from nominal stock returns, which is more volatile than inflation calculated from goods price. The reason is that the stock returns fully reflect to the market's expectation and investors' perception while the goods price is determined in goods market, which has sticky pricing mechanism. The higher volatility of pure price inflation rate would better capture the movement of exchange rate than the inflation from goods price. However, the pure price inflation rate must be extracted by

estimating the best surrogate, the ex post nominal risk-free rate, using the implication from the study of Fama and MacBeth (1973).

Assuming that Fisher equation (6) holds, equation (7) holds.

$$i = r + \pi \quad (6)$$

$$R_{it} = r_{it} + \pi_t \quad (7)$$

i denotes the nominal interest rate, r denotes the real interest rate, π denotes the inflation rate, R_{it} denotes the nominal rate of return on asset i , r_{it} denotes the real rate of return on asset i , and π_t denotes the inflation rate at time t .

Follow the C-R-X, the extracted inflation series is estimated by regressing Fama and MacBeth (1973) two-step regression on the three-factor model of Fama and French (Fama and French, 1993). Assuming that all real effects of all factors (include the real effect of inflation) are captured by the three factors, thus the π_t measures only pure price inflation.

The three-factor model can be shown as;

$$R_{it} - R_{ft} = \alpha_i + \beta_{i1}[Rm_t - R_{ft}] + \beta_{i2}SMB_t + \beta_{i3}HML_t + \varepsilon_{it} \quad (8)$$

R_{it} denotes the returns on industry i , R_{ft} denotes the nominal rate of return on risk-free asset, Rm_t denotes the value weighted return on the market portfolio, SMB_t denotes the returns on the small minus big size portfolio, HML_t denotes the returns on the high minus low book-to-market portfolio.

In practice, only the T-Bill rate (TB_{t-1}) can be observed. Thus, the TB_{t-1} is used instead of R_{ft} in the three-factor model. The equation (8) is rewritten as equation (9).

First step (time series regression)

$$R_{it} - TB_{t-1} = \alpha_i + \beta_{i1}[Rm_t - TB_{t-1}] + \beta_{i2}SMB_t + \beta_{i3}HML_t + \eta_{it} \quad (9)$$

$$\text{where } \eta_{it} \equiv (1 - \beta_{i1})[R_{ft} - TB_{t-1}] + \varepsilon_{it} \quad (10)$$

R_{it} denotes the returns on industry i , TB_{t-1} denotes the T-Bill rate proxy, Rm_t denotes the value weighted return on the market portfolio, SMB_t denotes the returns on the small minus big size portfolio, and HML_t denotes the returns on the high minus low book-to-market portfolio.

The TB_{t-1} is the expected risk-free return at

time t that is determined at the end of $t-1$ (or at the beginning of t). Thus, $TB_{t-1} = E_{t-1}[R_{ft}]$. From the relationship in the Fisher equation (6), $R_{ft} = r_{ft} + \pi_t$. Therefore, $TB_{t-1} = E_{t-1}[r_{ft} + \pi_t]$, $TB_{t-1} = r_{ft}^e + \pi_t^e$. According to this relationship, the equation (9) can be rewritten as equation (11).

Second step (cross-sectional regression)

$$R_{it} - \hat{\alpha}_i = \hat{R}_{ft} + \hat{\beta}_{i1}[Rm_t - TB_{t-1}] + \hat{\beta}_{i2}SMB_t + \hat{\beta}_{i3}HML_t + \varepsilon_{it} \quad (11)$$

$$\text{where } \hat{R}_{ft} = [(1 - \beta_{i1})r_{ft} + \beta_{i1}r_{ft}^e] + [(1 - \beta_{i1})\pi_t + \beta_{i1}\pi_t^e] \quad (12)$$

\hat{R}_{ft} denotes the *ex post* nominal risk-free rate (extracted inflation), r_{ft} denotes the real (risk free) interest rate, π_t denotes the pure price inflation rate, the notation “ e ” denotes the expected value.

The $\hat{\alpha}_i$ and $\hat{\beta}_{ik}$ $k = 1, 2, 3$ are estimated in the first step (time series regression). In the second step (cross-sectional regression), the returns on industry i minus the estimated alpha ($\hat{\alpha}_i$) are run against the estimated betas ($\hat{\beta}_{ik}$ $k = 1, 2, 3$) from the first step to estimate the \hat{R}_{ft} in each t . The \hat{R}_{ft} from the second step contains both pure price inflation and real interest rate. Assume that the real interest rate differential correlate with neither the pure price inflation differential nor the exchange rate differential, the \hat{R}_{ft} is used as an inflation proxy to test the short run PPP in equation (2). The test specification can be shown as;

$$\hat{R}_{ft} - \hat{R}_{ft}^* = \beta_1 + \beta_2 \Delta s_t + \varepsilon_t \quad (13)$$

\hat{R}_{ft} denotes the extracted inflation of home country, \hat{R}_{ft}^* denotes the extracted inflation of foreign country, and Δs_t denotes the change of log of domestic currency in the form of direct quoted.

For the long run test, the series of \hat{R}_{ft} estimated from the second step is used as inflation rate to construct the *HPI* follow this formula,

$$HPI_t = HPI_{t-1} (1 + \hat{R}_{ft}) \quad (14)$$

The *HPI* in the first period is set equal to 100. The series of *HPI* contain the \hat{R}_{ft} as a marginal price (inflation rate) in each t . Thus, the *HPI* is used as

a series of *price index* to test for the long run PPP in equation (3) and (5), which require the variable p_t and p_t^* in price level. The test specifications can be shown as;

$$q_t = s_t + HPI_t^* - HPI_t \quad (15)$$

$$\text{and } s_t = \beta_0 + \beta_1 (HPI_t - HPI_t^*) + \varepsilon_t \quad (16)$$

q_t denotes the log of real exchange rate, s_t denotes the log of nominal exchange rate, HPI_t^* denotes the log of hypothetical price index of foreign country, and HPI_t denotes the log of hypothetical price index of home country.

Traded-goods price index (TPI)

The TPI is constructed from import price index and export price index, weighted average by proportion of import expenditure and export expenditure from total trade expenditure, respectively.

$$TPI_t = \alpha_I MPI_t + \alpha_X XPI_t \quad (17)$$

MPI_t denotes the import price index, XPI_t denotes the export price index, α_I denotes import expenditure/total trade expenditure, α_X denotes export expenditure/total trade expenditure, and $\alpha_I = (1 - \alpha_X)$.

In short run, the TPI is tested in the form of inflation calculated from the index using equation (2). In long run, the TPI is tested at the index level using equation (3) and (5). The specifications can be shown as equation (18), (19), and (20), respectively.

$$\Delta TPI_t - \Delta TPI_t^* = \beta_1 + \beta_2 \Delta s_t + \varepsilon_t \quad (18)$$

$$q_t = s_t + TPI_t^* - TPI_t \quad (19)$$

$$s_t = \beta_0 + \beta_1 (TPI_t - TPI_t^*) + \varepsilon_t \quad (20)$$

ΔTPI_t denotes the traded-goods price inflation of home country, ΔTPI_t^* denotes the traded-goods price inflation of foreign country, Δs_t denotes the change of log of domestic currency in the form of direct quoted, q_t denotes log of real exchange rate, s_t denotes log of nominal exchange rate, TPI_t^* denotes the log of traded-goods price index of foreign country, and TPI_t denotes the log of traded-goods price index of home country.

RESULTS AND DISCUSSION

Short run PPP

In the case of extracted inflation, this inflation proxy contains both real interest rate and pure price inflation according to the equation (12). From this reason, the equation (2) when rewritten as equation (13); $\hat{R}_{ft} - \hat{R}_{ft}^* = \beta_1 + \beta_2 \Delta s_t + \varepsilon_t$, is observable counterpart to $(\Delta \text{real interest rate}) + (\Delta \text{inflation rate}) = \beta_1 + \beta_2 \Delta s_t + \varepsilon_t$. The estimated intercept (β_1) from the regression on the equation (13) is given by the mean of real interest rate differential between domestic and foreign country. Thailand, Taiwan, and South Korea are emerging country, while the U.S. is developed country. Thus, the real (risk free) interest rates are not in the same magnitude. Therefore, the estimated intercept (β_1) from the regression cannot be expected to be zero. As a result, this study expects only $\beta_2 = 1$ to be the evidence of short run PPP.

Referring to table 1, In the case of extracted

inflation in Thailand, the estimated coefficient of exchange rate differential (β_2) is significantly different from zero at 1% significance level. Moreover, the coefficient does not reject $\beta_2 = 1$ at even 90% confidence level, so the null hypothesis of PPP is not rejected. In the case of the same inflation proxy in Taiwan, the high standard error makes the estimated coefficient (β_2) is not significantly different from zero. However, the coefficient does not reject null hypothesis $\beta_2 = 1$ at even 90% confidence level. Thus, the hypothesis of PPP is not rejected. In the case of the same inflation proxy in South Korea, the estimated coefficient (β_2) is not significantly different from zero. Moreover, null hypothesis $\beta_2 = 1$ is rejected at 1% significance level. Therefore, the hypothesis of PPP is rejected in this case.

From the results of the tests using extracted inflation, it can be concluded that when the extracted inflation is used as inflation proxy, the evidences support short run PPP in Thailand and Taiwan while the evidences do not support short run PPP in the

Table 1 Results of short run PPP regression

| Country | Inflation proxy | Estimated coefficient | | | Hypothesis test |
|-------------|------------------------------|---------------------------------|------------|---------------|---------------------------------|
| | | β_1 | β_2 | Adj. R-Square | Ho: $\beta_2 = 1$ |
| Thailand | Extracted inflation | 4.38616 | 0.95969 | 0.06527 | <i>t</i> -statistic -0.11379 |
| | | (s.e.) (0.62460) | (0.35428) | | |
| | | <i>t</i> -statistics 7.02237*** | 2.70886*** | | |
| | Traded-goods price inflation | -0.01655 | 0.45163 | 0.25906 | <i>t</i> -statistic -6.47958*** |
| | | (s.e.) (0.10504) | (0.08463) | | |
| | | <i>t</i> -statistics -0.15751 | 5.33656*** | | |
| Taiwan | Extracted inflation | 2.10744 | 0.86252 | 0.00460 | <i>t</i> -statistic -0.18170 |
| | | (s.e.) (0.80704) | (0.75665) | | |
| | | <i>t</i> -statistics 2.61132** | 1.13991 | | |
| | Traded-goods price inflation | -0.08467 | 0.32379 | 0.15496 | <i>t</i> -statistic -8.31722*** |
| | | (s.e.) (0.07545) | (0.08130) | | |
| | | <i>t</i> -statistics -0.15751 | 5.33656*** | | |
| South Korea | Extracted inflation | 3.99117 | -0.36988 | -0.00586 | <i>t</i> -statistic -2.15504** |
| | | (s.e.) (1.19942) | (0.63566) | | |
| | | <i>t</i> -statistics 3.32759*** | -0.58189 | | |
| | Traded-goods price inflation | -0.150010 | 0.321749 | 0.13413 | <i>t</i> -statistic -7.98984*** |
| | | (s.e.) (0.14393) | (0.07210) | | |
| | | <i>t</i> -statistics -1.04221 | 4.46242*** | | |

Notes: This table reports the results of the regression on the specification $\Delta p_t - \Delta p_t^* = \beta_1 + \beta_2 \Delta s_t + \varepsilon_t$. The Newey-West adjusted standard errors are reported in parenthesis. In the case of estimated coefficients, ***, ** significantly different from zero at 1% and 5% significance level, respectively. In the case of hypothesis test, ***, ** reject null hypothesis at 1% and 5%, respectively.

case of South Korea. However, the limitation of asset pricing model in explaining stock returns in the process of inflation extraction has to be careful. The SMB and HML from Fama and French three-factor model do not perfectly explain stock returns as much as expected in the extraction approach. Thus, the estimated betas of SMB and HML from the first step (time-series regression) of Fama and MacBeth approach are not significant in some industries, especially in South Korea. When these estimated betas are used in the second step (cross-sectional regression), the estimated intercepts (\hat{R}_{ft}) are overshooting in some data points (t). Thus, the standard deviation of the \hat{R}_{ft} is high. From this reason, the standard error of the coefficient β_2 in the equation (13) is high in the case of Taiwan and South Korea. Furthermore, the adjusted R square in the case of extracted inflation is lower than the case of traded-goods price inflation in all countries. As a consequence, the test could be more precise evidence of pure price inflation if more appropriate asset pricing model can be identified.

In the case of traded-goods price inflation, the estimated coefficients of exchange rate differential (β_2) are significantly different from zero at 1% significance level in all countries. However, the coefficients reject null hypothesis $\beta_2 = 1$ at 1% significance level and reject the joint null hypothesis $\beta_1 = 0, \beta_2 = 1$ at 1% significance level (the result are not reported in the table). This means that the hypothesis of short run PPP is rejected in all countries when traded-goods price inflation is used as inflation proxy.

From the results of the tests using traded-goods price inflation, the traded-goods price inflation is significantly explained by exchange rate differential. This implies that there is relationship between traded-goods price inflation and exchange rate differential in Thailand, Taiwan, and South Korea. However, the hypothesis of short run PPP is rejected in these cases. Therefore, these cases cannot be concluded that short run PPP holds using the traded-goods price inflation. In the full study, the relative

value of CPI inflation of home country and traded-goods price inflation of foreign country is also tried to test short run PPP. The results cannot be concluded that short run PPP holds in all countries either (the results are not shown in this paper).

Long run PPP

In the case of strong PPP using real exchange rate constructed from HPI, the results of unit root test do not reject unit root at even 90% confidence level in all countries. Thus, the evidence to support strong PPP using HPI as price proxy cannot be found.

In the case of strong PPP using real exchange rate constructed from TPI, referring to table 2, the result from Perron (1989) method rejects unit root at 1% significance level in the case of Thailand. The rejection of unit root in this case is supported by the result from Phillips-Perron method (not shown in this paper for brevity). The conclusion is that the real exchange rate constructed from TPI in Thailand is stationary. Moreover, the result from cointegration test also confirms the strong PPP in this case. The cointegration between exchange rate and relative prices exists. The result from Log-likelihood ratio test indicates that the size of the normalized cointegration coefficient $[-1, 1.1834]$ is not far from unity in absolute term (the results are not shown in this paper for brevity). Thus, this case is the evidence of strong PPP. In the case of Taiwan and South Korea using the same price proxy, the results of unit

Table 2 Results of Perron (1989) unit root test

| Country | Price proxy | t -statistics |
|----------|-------------|-----------------|
| Thailand | HPI | -4.10990 |
| | TPI | -5.35641*** |
| Taiwan | HPI | -2.79669 |
| | TPI | -3.37012 |
| Korea | HPI | -3.59997 |
| | TPI | -3.11787 |

Notes: This table reports the results of unit root test by taking account of structural break. The method is Perron (1989).

*** reject null hypothesis of unit root at 1% significance level.

root test cannot be concluded that these two cases are stationary. Therefore, these two cases do not support strong PPP.

In the case of weak PPP using HPI, referring to table 3, the Johansen cointegration test indicates that the null hypothesis of *no cointegration* is not rejected at even 90% confidence level in all countries. These results indicate that the comovement between exchange rate and relative HPI does not present. Thus, the evidences do not support weak PPP in long run using HPI as price proxy in all countries.

In the case of weak PPP using TPI, trace statistic indicates that there is one cointegrating vector at 5% significance level in the case of Thailand. Furthermore, the result from Log-likelihood ratio test indicates that the size of the normalized cointegration coefficient [-1, 1.1834] is not far from unity in absolute term in this case (the result is not shown in this paper for brevity). Thus, these evidences support weak PPP. Moreover, this case also supports strong PPP as explained in the part of strong PPP. In the case of TPI in Taiwan, trace statistic indicates 2 cointegrating vectors at 1% significance level. The result from Log-likelihood

ratio test indicates that the size of the first normalized cointegration coefficient [-1, 1.5606] is not far from unity in absolute term (the result is also not shown in this paper). Therefore, this case supports weak PPP. In the case of TPI in South Korea, both trace and maximum eigenvalue statistic indicate that the null hypothesis of *no cointegration* is not rejected at even 90% confidence level. Thus, this case does not support weak PPP.

As a conclusion of the results from long run test, the results support strong PPP in the case of Thailand using TPI as price proxy. Moreover, the results support weak PPP in the case of Taiwan using TPI as price proxy. In other cases, the results do not support any form of long run PPP.

From the results of the tests in both short run and long run, the conclusion is that the extracted inflation (\hat{R}_{fi}) supports the short run PPP, but does not support the long run PPP. However, there are some differences between the results interpretation in the short run and in the long run. In the short run test, the coefficient (β_2) can be interpreted as an explanation of exchange rate differential to inflation differential, while the intercept (β_1) can be interpreted as interest rate differential. On the contrary, in the

Table 3 Results of Johansen cointegration test

| Country | Price proxy | Lag | Trace | | | Maximum eigenvalue | | |
|-------------|-------------|-----|-------|------------|----------|--------------------|------------|----------|
| | | | Ho | Statistics | p -value | Ho | Statistics | p -value |
| Thailand | HPI | 2 | r<0 | 3.7316 | 0.9240 | r=0 | 3.5494 | 0.9036 |
| | | | r<1 | 0.1822 | 0.6695 | r=1 | 0.1822 | 0.6695 |
| | TPI | 4 | r<0 | 19.7870** | 0.0106 | r=0 | 12.9844* | 0.0788 |
| | | | r<1 | 6.8026*** | 0.0091 | r=1 | 6.8026*** | 0.0091 |
| Taiwan | HPI | 3 | r<0 | 8.9116 | 0.3736 | r=0 | 8.4466 | 0.3351 |
| | | | r<1 | 0.4649 | 0.4953 | r=1 | 0.4649 | 0.4953 |
| | TPI | 2 | r<0 | 20.6695*** | 0.0076 | r=0 | 12.9185* | 0.0807 |
| | | | r<1 | 7.7510*** | 0.0054 | r=1 | 7.7510*** | 0.0054 |
| South Korea | HPI | 2 | r<0 | 5.5710 | 0.7455 | r=0 | 5.1768 | 0.7194 |
| | | | r<1 | 0.3943 | 0.5301 | r=1 | 0.3943 | 0.5301 |
| | TPI | 2 | r<0 | 8.7413 | 0.3899 | r=0 | 8.2159 | 0.3572 |
| | | | r<1 | 0.5253 | 0.4686 | r=1 | 0.5253 | 0.4686 |

Notes: This table reports the results of Johansen cointegration test on the relationship $s_t = \beta_0 + \beta_1(p_t - p_t^*) + \varepsilon_t$. "r" denotes no. of cointegrating vector. ***, **, * reject null hypothesis at 1%, 5%, and 10% significance level, respectively.

long run test, the result of HPI just indicates the combined effect of pure price inflation and real interest rate because these two factors cannot be separated from each other before the construction of HPI. As a result, in long run, the result of the pure price inflation cannot be concluded.

The TPI does not support PPP in short run, but does support in long run (in the case of Thailand and Taiwan). This may come from price behavior. In short run, the traded-goods price cannot capture the movements in financial market as good as the extracted inflation because goods price is sticky. However, in long run, the index of traded-goods price has better comovement with exchange rate than the HPI and the domestic CPI-foreign TPI (tested in the full study). The reason is that the equilibrium exchange rate level is determined by the equality of purchasing power between two countries through arbitrage mechanism. Thus, the purchasing power refers to the purchasing power of tradable goods. This means that TPI is more appropriate for long run PPP.

The results of TPI in each case of long run test are not the same because of the different economic environments in each country. The long run PPP can be valid through arbitrage mechanism, which might take too much time to active in short run. Thus, the validity of PPP in long run is highly affected by the factors that relate to trading activity. This conclusion is supported by the trading indicators of Thailand and Taiwan, in which the evidences to support long run PPP are found. Among the three countries, Thailand has the highest trade to GDP ratio in 2003 - 2008 and Taiwan has the highest average portion of trading value with the U.S. to total trading value with all countries in 1998 - 2007. Moreover, Taiwan has the lowest Most Favored Nation (MFN) tariff rate around 2006 - 2008. On the contrary, South Korea has the highest MFN tariff rate around 2006 - 2008. In addition, the main export good of South Korea to the U.S. is the road vehicles, which has high cost of transportation. Moreover, the price of this good is almost impossible to equal between countries

because of the pricing-to-market strategy. This would be the explanation why the results support long run PPP using TPI just in the case of Thailand and Taiwan, not in the case of South Korea.

About the CPI, the CPI contains high portion of non-tradable goods that cannot be arbitrated. Therefore, the evidence of PPP cannot be found when tested by the combination of this price proxy.

CONCLUSION AND RECOMMENDATION

In short run, the hypothesis of PPP is not rejected at 95% confidence level in the case of Thailand and Taiwan using extracted inflation as inflation proxy. However, the hypothesis of PPP is rejected at 5% significance level in the case of South Korea using extracted inflation as inflation proxy and the cases of all countries using traded-goods price inflation as inflation proxy.

The results of the short run test in the case of Thailand and Taiwan provide the additional supporting evidences that PPP seems to be valid in short run when using pure price inflation rate extracted from stock return due to high-volatility of pure price inflation rate comparing to inflation from good prices. In the traditional tests of PPP, the inflation rates from goods price always do not satisfy short run PPP since goods price takes longer time period in adjustment than stock prices. From this reason, the evidences of the extracted inflation support short run PPP while the evidences of traded-goods price inflation do not support short run PPP in the same country and sample period.

In long run, the results of unit root test and cointegration test support strong PPP in Thailand using TPI as price proxy. The results also support weak PPP in Taiwan using TPI as price proxy. In other cases in long run, the test results do not support PPP.

The factors that have high effect to the long run PPP are the factors that relate to trading activity, such as trading value, tariff rate, and type of export

goods. High international trading activity means high opportunity of arbitrage mechanism. Therefore, PPP should be valid with the country that has higher level of factors that support international trading activity rather than the country that has lower level of those factors.

From the evidences of the extracted inflation in short run and the TPI in long run, these two proxies could be applied as the other inflation proxies in the relationship of PPP, which is used in exchange rate determination and exchange rate forecasting. However, since the extracted inflation contains both pure price inflation and real interest rate, this inflation proxy should be adapted before using in further study. The appropriate method to separate or estimate the pure price inflation from the extracted inflation should help this inflation proxy be more applicable.

SUGGESTIONS FOR FURTHER STUDY

In further study, it is interesting to examine the evidence of the extracted inflation in other countries. There are some important points:

1. In the process of inflation extraction, the asset pricing model with higher power of explanation can give the extracted inflation series with lower noises. The high power model benefits to the test. Thus, the power of explanation of the asset pricing model is important to concern in the process of inflation extraction of C-R-X.

2. In the process of long run PPP test, the extracted inflation is used to construct price index series (HPI) before the unit root and cointegration tests. However, the extracted inflation contains both pure price inflation and real interest rate. If these two components can be separated from each other by appropriate method, the evidence of the extracted inflation in long run will be shown more clearly.

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